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Renewing the Shelterbelt

G. B. MacDonald
Iowa State College

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Abstract
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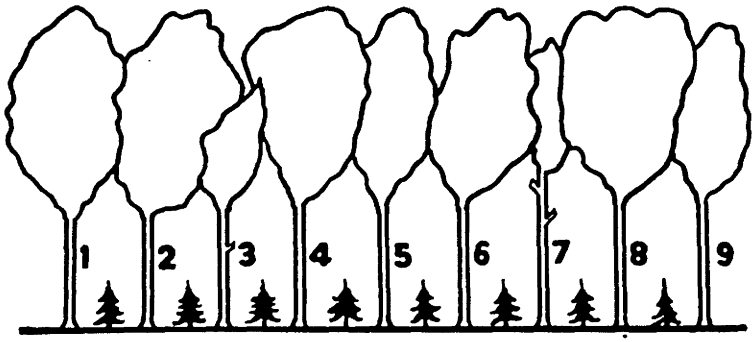

In cover figure the new generation of trees have grown for five years under the old stand. Even shade-enduring trees, although getting a start, will not make a satisfactory growth in the dense shade of other trees, consequently the old stand should be opened up either gradually or at one operation.

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Forestry Section

Ames, Iowa

RENEWING THE SHELTERBELT

BY G. B. MACDONALD

In removing the old decaying shelterbelt and replacing it with younger and better trees, it is not necessary to lose its protective value during the process. By following any one of the methods described in this circular the old stand of trees may be cut out and a new stand of the same or some other species secured while keeping the shelterbelt in a more or less effective condition.

On many farms in Iowa there is need of renewing the old shelterbelts. They were planted in the early days mainly for protection and and were made up of quick-growing, short-lived trees, such as the soft maple, cottonwood, willow and boxelder, having been planted heavily in the central and northern sections of the state. Some of these shelterbelts have yielded good returns in fuel and lumber in addition to affording protection to farm buildings. Others, through the trampling of stock and other causes, have yielded only small returns in wood products and only a little more in protection. Most of these short-lived groves which are still uncut are in various stages of decay and in many instances should be replaced with new stands of of longer lived species.

Five different methods for renewing shelterbelts in Iowa are presented in this circular: By renewing from one side; by renewing from two sides; by renewing by clear cutting; by renewing in alternate rows; by renewing by underplanting. Each method is illustrated with drawings which explain how the work is carried on for a shelterbelt of average size. Whatever system is used must be so adapted that it will meet the local conditions found in the shelterbelt that is to be renewed.

REGENERATION FROM ONE SIDE

In this method the object is to replace the present stand of trees gradually without losing much of the grove's protection value. If the grove is so old or in such poor condition that it will not hold together during the 15-year period required for regeneration, another system should be used which will take a shorter time.

METHOD OF REMOVING THE OLD TREES

Figures 1 to 5 show how the cuttings should proceed. In the case illustrated, it is assumed that the plantation is composed of 9 rows and that the trees will last at least 15 years longer. The rows run east and west and the grove is situated just to the north of the farm buildings.

First Step: During the winter or early spring remove all of the trees in the two south rows (8 and 9), leaving seven rows of trees for protection for the farm buildings. During the spring the blank rows should be planted up, preferably to one of the evergreen species mentioned later. The two new rows of trees will receive an abundance of light from the top and south side and also will be protected from wind damage by the old trees, which will insure a good growth. The new rows should be fully protected from stock and surface fires. Cultivation for several years will keep out weeds and grass and will increase the rate of growth.

Second Step: Five years from the time the two south rows are removed, cut out the next two (6 and 7) and replant in much the same manner as the first two. Great care should be exercised in felling the large trees so as not to damage the newly planted rows. At this time also replant the fail spots in rows 8 and 9.

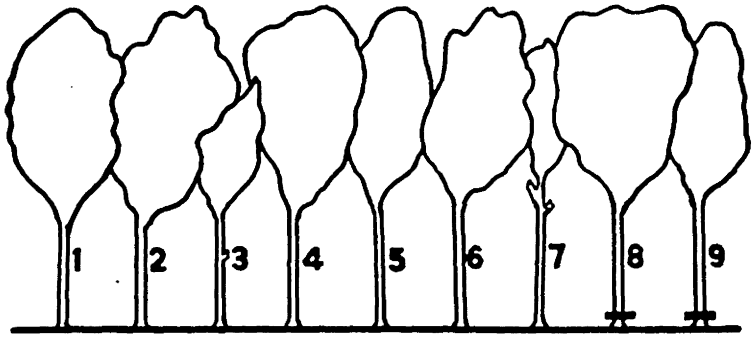

Fig. 1. Rows 8 and 9 are to be cut out first and planted up the same year with young trees of the new species.

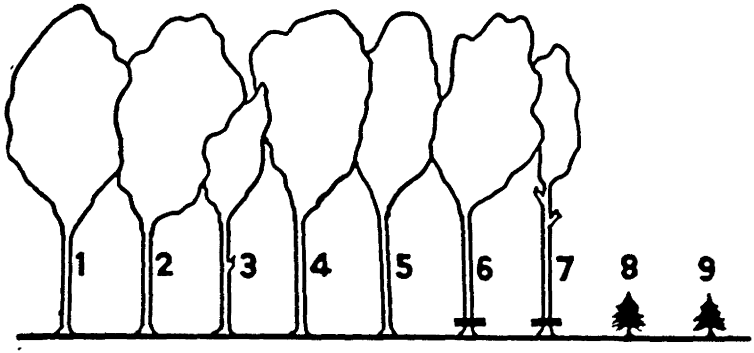

Fig. 2. At the end of 5 years, rows 6 and 7 are cut out and replanted. By this time the new trees in rows 8 and 9 should have made a good start.

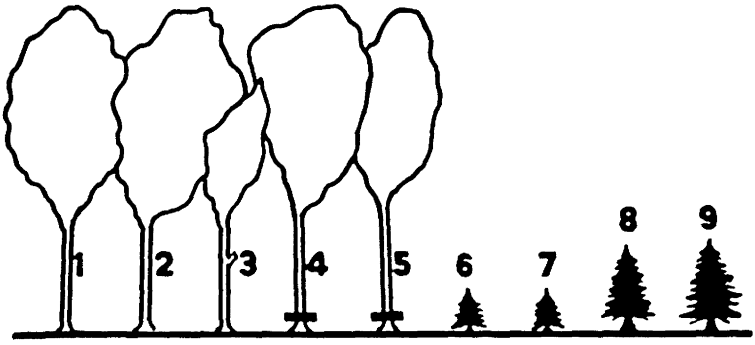

Fig. 3. After 10 years, rows 4 and 5 are cut out and planted. The new trees in rows 6 and 7 have made a good growth and those in rows 8 and 9 are large enough to give some protection.

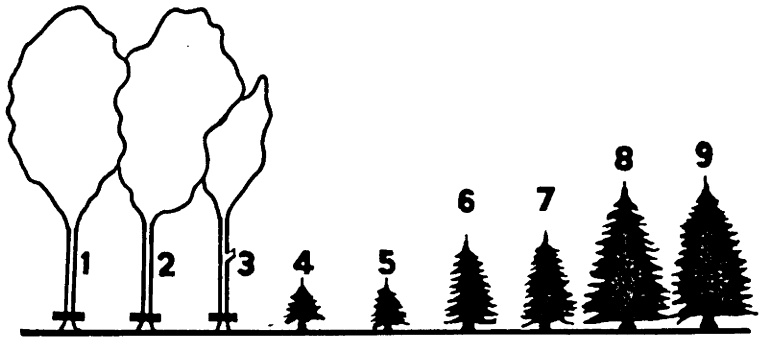

Fig. 4. After 15 years, the remaining rows, 1, 2 and 3, are cut out and replanted.

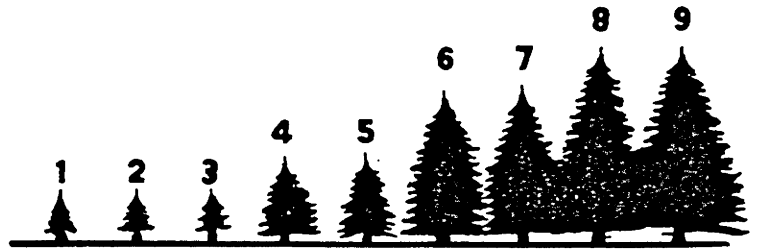

Fig. 5. After 20 years, the last rows, 1, 2 and 3, are 5 years old and 8 and 9, are 20 years old. The regeneration of the shelterbelt is completed.

Third Step: After another five-year period has elapsed, cut out rows 4 and 5 and replant them. This leaves but three rows of the old trees for giving protection. By this time, however, if broadleaf trees or fast-growing evergreens have been used for planting, the trees in rows 8 and 9 should be large enough to give good wind protection themselves, thus reinforcing the old rows remaining.

Fourth Step: After the third five-year period, cut out the remaining three rows of old trees and replant. If the plantings are successful, the regeneration is completed.

USE OF THE METHOD FOR DIFFERENT SHELTERBELTS

The method of regeneration from one side is adaptable to groves of any species, since the successive cuttings progress in a way to give an abundance of light to the new growth, no matter what the original grove is composed of.

Cottonwood: The cottonwood matures at an age of 35 to 40 years. It requires an abundance of light for growth and, as a result, stands of this species are relatively open. Many of these shelterbelts in the state are 35 to 40 years old and, under usual conditions, will last long enough for the application of this system of regeneration.

There will be difficulty in using the old trees for lumber, since it usually would not be profitable to bring in a portable sawmill every

few years for cutting up small amounts of lumber. However, where the plantation is large enough, the lumber can be used profitably for rough construction work on the farm. Round, split or sawed fence posts made from cottonwood trees will last for 25 years if given a good treatment with creosote.* In most sections of the state the wood has a ready value for fuel on the farm.

Soft Maple: Soft maple trees are quite tolerant of shade and, consequently, grow in a dense stand. The dense shading on the interior of the average soft maple grove makes it impossible to grow successfully under the old stand any except the most shade-enduring trees. However, under the regeneration method just described, the new trees are established outside of the grove proper, where shading interferes but little. Like the cottonwood, the soft maple is a short-lived tree and regeneration by this method should begin by or before the fortieth year if possible.

The relatively small number of maple trees removed periodically under this system should generally be used for fuel or fence posts. Soft maple fence posts when given a treatment of creosote, at a cost of 10 to 15 cents per post, will last for a period of 25 years.

Willow: The willow is also short-lived and the application of this method should be begun preferably before the trees are 35 years old. The willow sprouts persistently from the stump after the trees are cut down and usually considerable trouble is experienced in killing the sprouts. If the trees are cut in August, instead of in the winter, very few sprouts appear, and if these are promptly removed the stumps soon die. Under present conditions the willow has few uses except for fuel. However, after treatment with creosote, willow fence posts last for a long period of years and the wood from the old shelterbelt might profitably be used for this purpose.

Boxelder: Boxelder trees, although moderately rapid in growth, are always crooked, of small size and very short lived. They have little value except for wind protection. The regeneration by the method just described, should be begun as early as possible, even in young plantations. In old plantations (35 years), it is sometimes desirable to renew the grove by a quicker method, such as the clear-cutting system (see figs. 11, 12, 13 and 14). Use the trees removed for fuel or, if straight enough, for fence posts. Posts treated with creosote last as well as the cottonwood, soft maple and willow after treatment.

TREES ADAPTED FOR PLANTING

Practically any tree suited to the climatic, soil and moisture conditions can be safely regenerated under this first system. The selection of the variety or varieties to be used must be largely governed by the uses to which the shelterbelt is to be put and also by the likes and dislikes of the owner. If the new grove is to serve efficiently as a shelter from the winter winds, at least a portion of the new planting should consist of evergreens. If it is to serve also as a source of fuel, fence posts, and lumber, the trees best adapted for these purposes should make up a part of the new plantation. Care should be exercised in mixing species, so as not to have a row of fast-growing trees, such as some of the hardwoods, overtop and shade out previously planted rows of a slower growing, intolerant species such as the Austrian, Scotch, or western yellow pines.

The following evergreen trees, when only one species is used, are adapted for planting in regeneration from one side:

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*See Bulletin 158, Iowa Agricultural Experiment Station. "The Preservative Treatment of Fence Posts."

White Pine: One of the most rapid-growing evergreen trees. Will grow on any except a poorly drained soil. A good windbreak tree when spaced 10 feet apart, in rows 12 feet apart. Produces saw lumber in 40 to 50 years. For this purpose it should be spaced 8 x 8 feet apart. Will endure a slight amount of shading when young.

Red Pine: Fairly rapid growth. Good for any but a wet soil. Will not endure shading.

Austrian Pine: Very hardy. Good for dry situations. Slower in growth than the white pine. Will not stand shading.

Western Yellow Pine: A hardy western tree suitable for dry situation. Similar to the red pine but of slower growth. Very intolerant of shade.

Norway Spruce: The best spruce for Iowa planting. Has a dense foliage and branches to the ground. Will stand shading. Should not be planted on very dry situations.

White Cedar: A shade-enduring evergreen of slow growth, making a good shelterbelt tree. It is not suitable for dry upland planting but will endure rather wet soils.

Red Cedar: A good windbreak tree. Suitable for very dry situations and soils of poor quality. Should not be planted near apple trees because of fungus trouble. Will stand shading.

European Larch: A tall, straight tree suitable for planting on good soils. Intolerant of shade. Not best for winter protection, since it sheds its leaves annually. Produces good pole timber.

Other evergreens which might be planted, but which are less desirable than the above, are the jack pine, Scotch pine, white spruce, and Douglas fir.

Broadleaf trees which might profitably be planted are the following:

Cottonwood: The fastest growing tree in Iowa. Good for quick results, but short-lived. Intolerant of shade. Will make fence posts*, in six years and saw logs in 25 years on good soil.

Soft Maple: Fairly rapid grower. Will stand close spacing, and some shading. Short-lived. Can be utilized for fence posts (creosoted) and for fuel.

Hardy Catalpa: A small tree requiring full light. Good for fence posts. Should not be planted on exposed situations in northwestern Iowa without protection of other rows of trees.

Black Walnut: A fairly rapid grower, forming an open stand. Requires a moist soil. Is very intolerant of shade. Valuable for lumber but does not make a very effective windbreak tree, due to the thinness of its foliage.

Honey Locust: A fairly rapid grower. Intolerant of shade. Makes good posts.

Osage Orange: Not hardy in northern half of Iowa. A good fence post tree. Intolerant of shade.

Russian Mulberry: A small tree, giving protection close to the ground. Very tolerant and drought resistant. Not hardy in northern Iowa. Wood very durable.

Green Ash: A medium-sized tree of moderate growth and quite hardy. Makes fair fence posts.

A large number of hardwood trees might be added to the above list, but in planting, care should be taken to select only those trees adapted to the local climatic and soil conditions.

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*Cottonwood posts are not durable unless treated with a preservative.

COMBINATIONS OF SPECIES FOR PLANTING

Various combinations of trees may be planted under this system of regeneration from one side, but, as a rule, two or three species are sufficient. If the rows are to be of different varieties, the principal care should be to see that the rapidly-growing hardwoods do not overtop and suppress the slow-growing trees. The intolerant evergreens, being of slow initial growth, are in more danger of being overtopped than the hardwood trees.

The following are some of the combinations which might be used:

Combination No. 1. Rows 8 and 9, white pine; rows 6 and 7, Norway spruce; rows 4 and 5, European larch; rows 1, 2 and 3, white pine.

Combination No. 2. Rows 8 and 9, white cedar or Norway spruce; rows 4, 5, 6 and 7, white pine, red pine or Austrian pine; rows 1, 2 and 3, white cedar or Norway spruce.

Combination No. 3. Rows 8 and 9, European larch (bare in winter); rows 6 and 7, white cedar or red cedar;* rows 4 and 5, Norway spruce or white spruce; rows 1, 2 and 3, cottonwood.

Combination No. 4. Rows 8 and 9, white cedar, Norway spruce or white pine; rows 6 and 7, red pine, Austrian pine, western yellow pine, or Douglas fir; rows 4 and 5, Norway spruce or white cedar; rows 1, 2 and 3, hardy catalpa.

Combination No. 5. Rows 8 and 9, white pine; rows 6 and 7, Norway spruce or white cedar; rows 4 and 5, cottonwood; rows 1, 2 and 3, green ash, or Russian mulberry.**

VARIATIONS IN THE METHOD

In this first regeneration process, the five-year period between successive cuttings need not necessarily be adhered to. The period might be reduced to three years or less. In the case of a shelterbelt composed of three or four rows of old trees, only one row should be cut at a time, unless the trees are in very poor condition.

REGENERATION FROM TWO SIDES

In this method it is also the purpose to secure a new growth of trees without sacrificing entirely the efficiency of the windbreak. By reference to the diagrams in the figs. 6 to 10, it will be noted that instead of a gradual removal of the trees from one side, as was the case in the first method, single rows are taken from each side at intervals of five years. The time between the first and the last planting is the same as in the first method of cutting—15 years.

Figures 6 to 10 show how the cuttings should proceed. In the case illustrated, it is assumed that the shelterbelt is composed of nine rows of trees, most of which will last through the regenerative period of 15 years.

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*Red cedar should not be planted if apple trees are in the vicinity because of fungus trouble.

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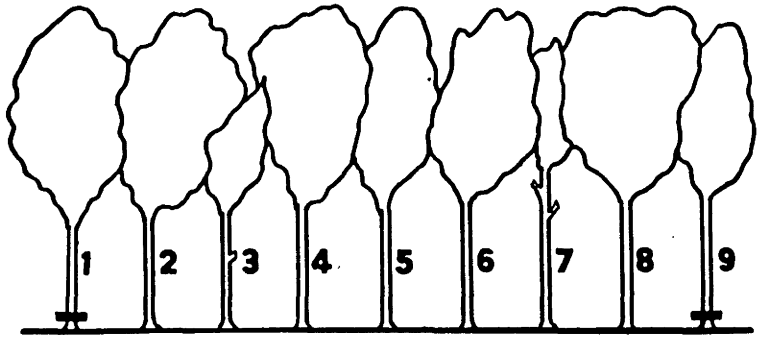

Fig. 6. At the beginning the two outside rows, 1 and 9, are cut out and replanted the same year with young trees of the new species.

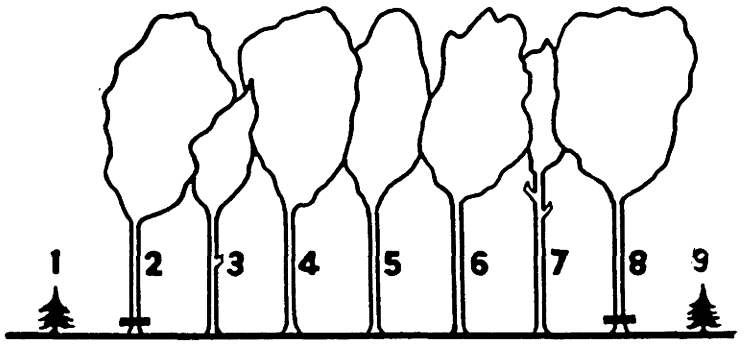

Fig. 7. After 5 years, rows 2 and 8 are cut out and planted with new trees; the trees in rows 1 and 9 are 5 years old.

At the beginning, rows 1 and 9 of the old plantation are cut out and replanted to the new species. Five years later rows 2 and 8 are taken out, and after another period of five years, rows 3 and 7 are removed. At the last cutting, rows 4, 5 and 6 are replaced with young trees. It will be seen that fair protection from the wind is afforded by the old trees, even up to the last cutting, and by this time some of the newly-planted trees should be sufficiently high to give some protection.

USE OF THE METHOD FOR DIFFERENT SHELTERBELTS

This second method should be almost as successful in regenerating short-lived shelterbelts of cottonwood, soft maple, willow and boxelder, as the method of planting up from one side. There is one slight disadvantage; the new trees planted directly north of the old rows will receive less light than those planted to the south, consequently, some care should be exercised in the selection of species for planting. The shading is most severe in the cases of soft maple and boxelder shelterbelts, since the foliage of these trees is much more dense than that of the cottonwood or willow.

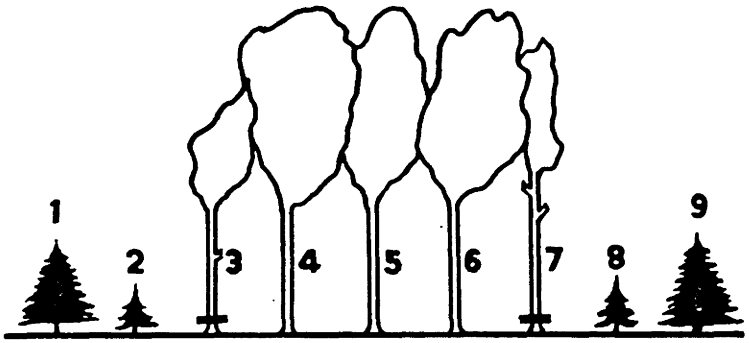

Fig. 8. After 10 years, rows 3 and 7 are cut from the shelterbelt and replanted.

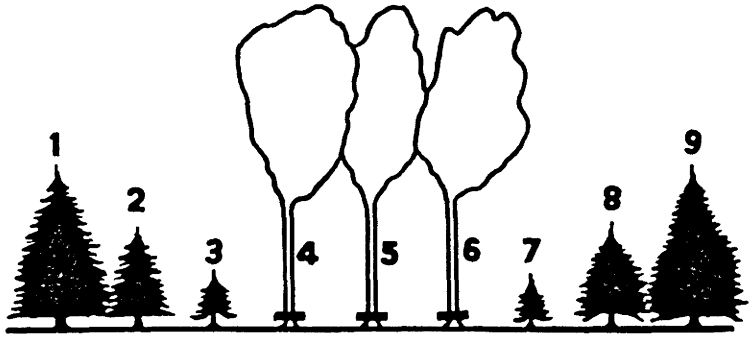

Fig. 9. After 15 years, the remainder of the old planting, rows 4, 5 and 6, are cut out and replanted.

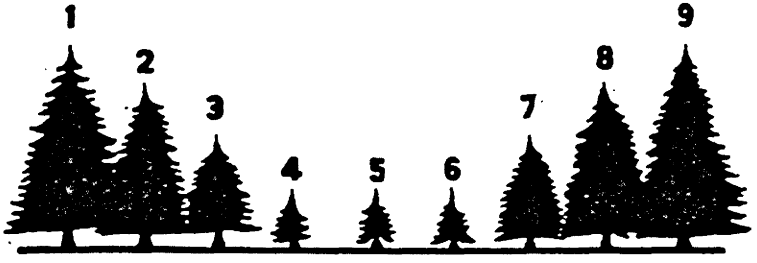

Fig. 10. After 20 years the youngest trees, in the interior of the grove, rows 4, 5 and 6, are 5 years old and the oldest, rows 1 and 9, are 20 years old.

In the case of groves which should be replaced at once with new trees, employ the clear-cutting system rather than the above plan. However, it is seldom that a plantation, even of the short-lived species, is so far gone that it will not remain in fair condition for 10 to 15 years. This method has certain disadvantages over the first, since it is more difficult to cut out the old trees in single rows without damaging the newly-planted ones. This is especially true when the original spacing of the trees is close.

If the old timber is to be utilized for lumber, difficulty may be experienced in getting a small number of trees sawed at a reasonable price. However, if the woodlot is to be used for fuel or fence posts, the timber can be cut economically for these purposes.

SPECIES USED IN REPLANTING

The list of species suitable for planting under this method is almost identical with the one given under the preceding first system. It should be borne in mind, however, that the newly planted trees to the north of the old rows will receive less light than those planted on the south side. As a result, if this shading appears to be excessive, trees which are somewhat tolerant of shade should be selected for this portion of the new shelterbelt.

It is very often desirable to have a shelterbelt of evergreen and hardwood trees. As a rule, the evergreens give good protection close to the ground and also serve as an effective windbreak throughout the year, while the larger hardwoods break the wind, at a distance from the ground but are not as effective during the winter months.

Combination No. 1. Rows 1 and 9,white pine; rows 2, 3, 7 and 8, Norway spruce; rows 4, 5 and 6, cottonwood.

The white pine rows being on the outside, receive an abundance of light at all times for best development. The Norway spruce on the interior will receive sufficient light for good growth, since they are very tolerant of shade. The cottonwoods in rows 4, 5 and 6, although planted last, would reach a height greater than any of the evergreen trees in a few years.

Combination No. 2. Row 1, Norway spruce; row 9, white pine; rows 2 and 8, white cedar; rows 3, 4, 5, 6 and 7, hardy catalpa.

The white pine trees in row 9 are not only effective as a windbreak, but also make a very beautiful row to face the farm buildings. The Norway spruce used in row 1, branches very close to the ground, has dense foliage, and, consequently, would be very effective in breaking the force of the wind. The white cedar, if closely spaced, makes a dense mass of foliage and is valuable for windbreak purposes. Although the hardy catalpa in the inside rows does not make a large tree, it is very desirable for fence posts. It is assumed in this combination, that the hardy catalpa rows can be harvested for fence posts in 12 years. Since the catalpa trees in rows 4, 5 and 6 are planted five years later than those in rows 3 and 7, the branches of the older trees should be trimmed back if there is danger of the later planting being shaded too severely. The catalpa is very intolerant of shade and will not thrive if overtopped by adjoining trees.

Combination No. 3. Row 1, white pine; row 9, white cedar; rows 2, 3, 7 and 8, Norway spruce; rows 4, 5, and 6, white pine.

The white pine in the interior rows, although planted last, is sufficiently rapid in growth to prevent its being overtopped by the

adjoining rows of Norway spruce, although the latter are planted five years earlier.

Combination No. 4. Rows 1 and 9, white cedar; rows 2 and 8, Norway spruce; rows 3, 4, 5, 6 and 7, cottonwood.

The evergreens on each flank of the shelterbelt will give efficient protection against the wind close to the ground and, at the same time, will give a pleasing effect to the windbreak both in summer and winter time. The interior of the plantation will, in a few years, not only break the force of the wind at some distance from the ground, but also be a profitable source of saw timber or fuel.

Combination No. 5. Row 1, white pine; row 2, white cedar; row 3, white spruce; rows 4, 5 and 6, red cedar;* row 7, Jack pine; row 8, western yellow pine; row 9, European larch.

The above combination makes an effective shelterbelt of coniferous species. The larch trees in row 9 shed their leaves during the winter.

VARIATIONS IN THE METHOD

It will seldom happen that the plan illustrated under this method will exactly fit conditions found in other shelterbelts. The method should be considered as suggestive and altered to suit local conditions. In the case of a shelterbelt which has only three or four rows, it would no doubt be preferable to use the system of regeneration from one side, taking out one row at each period instead of two rows. In the case of a plantation much wider than the one illustrated, it might be preferable to take two rows of trees at a time from each side instead of one row. There is no necessity of adhering to a uniform period of five years between cuttings. This may be either lengthened or shortened to suit convenience or necessity. On the other hand, a plan should be prepared and the work should follow a definite schedule or the regeneration will unquestionably prove a failure.

REGENERATION BY CLEAR-CUTTING

The method of clear-cutting is only employed when the windbreak can be dispensed with while the new stand of trees is growing, or where the old timber is in such poor condition that it must be renewed at once. Under such conditions, it is advisable either to cut everything on the plantation or to leave only a row or two to give some protection for a few years.

Under this system it is advisable, where conditions will permit, to leave two rows of the old trees after the first cutting, these rows to be removed during the second and third steps, respectively, in the regeneration process. (See figs. 11, 12, 13 and 14.)

The system has several advantages. In cases where the old plantation is to be cut into lumber (cottonwood for example), the trees can be sawed at a minimum cost, since most of the plantation is removed at one time. In addition, by removing practically all of the stand at once and replanting, there is no damage to the new stand of trees. On the other hand, where the timber is to be used for fence posts and fuel, it very frequently happens that there is not

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*Red cedar should not be planted in the vicinity of apple trees.

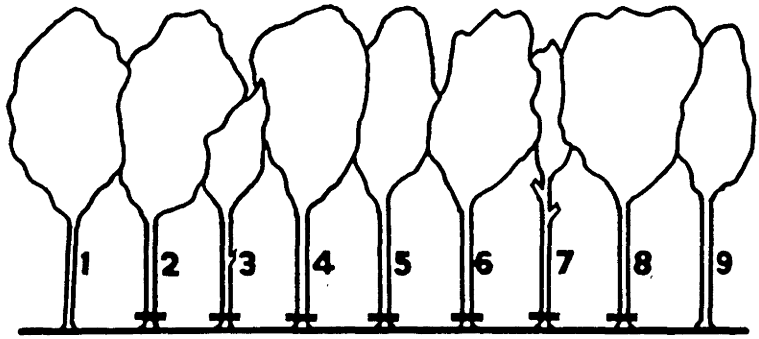

Fig. 11. At the beginning, rows 2, 3, 4, 5, 6, 7 and 8 are cut out. The rows are replanted the same year to either evergreen or broadleaf trees. The original trees in rows 1 and 9 are left temporarily for shelter and also to give some protection to the new crop of trees.

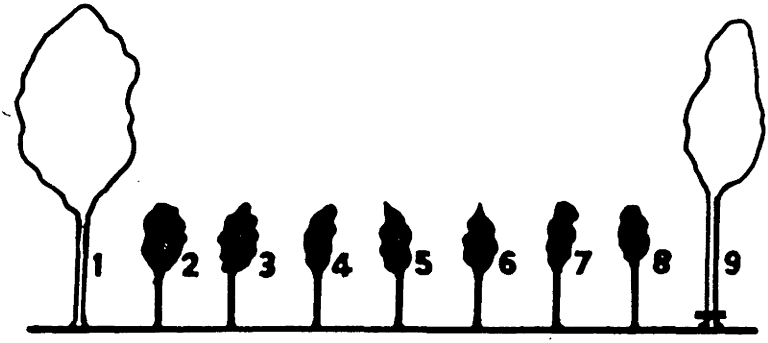

Fig. 12. After 5 years the trees in row 9 are cut out and replanted. The old trees in row 1 preserve partly the effectiveness of the shelterbelt at some distance from the ground. If the interior trees are of the broadleaf class the effectiveness of the shelterbelt would eventually be increased by planting evergreens in row 9.

a market for this material except on the home place. Consequently, it would entail a great waste of material, through decay, to store up for a number of years a supply of fuel or posts made up of undurable woods.

At the beginning of the regeneration period, all except the two outside rows of trees are removed and replanted. After five years' time, the south row (no. 9) is removed and replanted. At the close of another five-year period the last row of old trees (no. 1) is replaced. The outside rows being more thickly branched will give fair protection against the wind. In case the trees are in such poor condition that they will not last for even a few years, it would then be desirable to take out all of the old trees at the first cutting. Under such circumstances, a portion of the new growth should be made up of the most rapidly growing trees available, in order that the grove may become effective against the wind as soon as possible.

The clear-cutting method, from a cultural standpoint can be more generally applied than any of the other systems suggested. In a pure plantation, established at one time, there is less danger of excessive crowding and overtopping, since the trees are equal in rate of growth and shade-enduring qualities. If the new shelterbelt is to

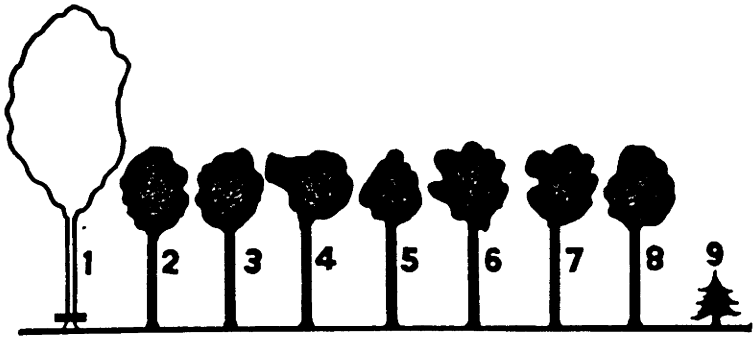

Fig. 13. After 10 years the newly planted trees are large enough to permit the removal of the remaining old trees, row 1, without injury. This row should be planted the same year.

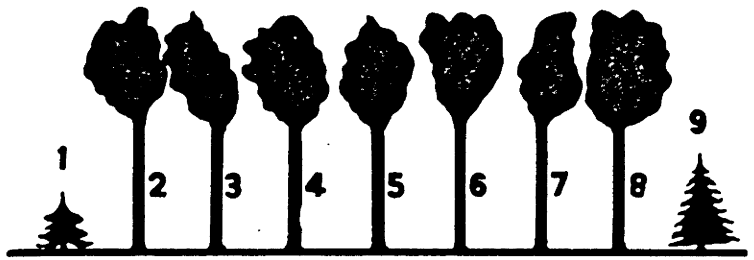

Fig. 14. After 15 years the regenerated shelterbelt should give good protection.

be composed of different species, care must be exercised in the selection of combinations, to prevent overtopping and killing the slower growing or intolerant trees.

This system should be applied to cottonwood, soft maple, willow and boxelder shelterbelts which are too old or degenerate to be satisfactorily regenerated by one of the slower methods, or where the protective feature of the grove is not of great importance.

SPECIES USED IN PLANTING

When one species is to be used throughout the entire shelterbelt, any tree which is suited to the climatic, soil and moisture conditions of the locality may be used. The following is a partial list of trees which might be used: Cottonwood, hardy catalpa, soft maple, hard maple, black walnut, red oak, white pine, red pine, Austrian pine, western yellow pine, Norway spruce, European larch, red cedar, white cedar.

COMBINATIONS FOR REPLANTING

Combination No. 1.

The Norway spruce, white cedar or red cedar might be alternated with the cottonwood or other thin-crowned, fast-growing species. These evergreens are tolerant of shade and would make a fair growth under the light shade of trees such as the cottonwood.

Combination No. 2.

Norway spruce and white cedar, where conditions are suitable, might be planted in alternate rows. After 30 to 35 years, the Norway spruce begins to overtop the white cedar, but the combination makes one of the most efficient shelterbelts that can be grown in Iowa.

Combination No. 3.

Any broadleaf species suitable for the region might be used on the interior rows of the plantation, these rows to be flanked by the planting of any evergreen suiting the locality, in the outside rows 1 and 9.

Combination No. 4.

Alternating rows of European larch and Norway spruce. The European larch when planted alone makes a rather open stand. The tolerant Norway spruce, being of slower growth, will form an under story which will keep out grass and weeds, benefiting both species.

VARIATIONS IN THE METHOD

One block, making up from one-fourth to one-half of the plantation, might be renewed in one year, and the balance of the plantation in the years immediately following. This would distribute the planting over several years, which might be advantageous under certain conditions.

REGENERATION BY ALTERNATE ROWS

The method of regeneration by planting alternate rows may well be used in shelterbelts where the original spacing is wide. Many cottonwood plantations might be renewed by this system. Disadvantages are to be found, however, in the fact that only the shade enduring species can be used for planting between the old rows left standing after the first cut and, later, when the remaining old trees are removed it is practically impossible to fell the timber without damaging the young trees which have been planted.

Under this system the entire stand of old trees is removed in two cuttings. The second cutting should generally follow the first after about 10 years, but this period can either be shortened or lengthened to suit conditions (see figs. 15, 16 and 17.) Fairly good windbreak protection will be afforded until time for the last cutting of the old timber. At this time, unless the period between cuts has been of considerable length, the efficiency of the windbreak is likely to be impaired for a number of years, inasmuch as the tolerant trees which are used in replanting are generally of slow growth and will not be tall enough to give much protection against the wind in a period less than fifteen or twenty years.

This system could be used in certain cases in cottonwood or willow plantations which are rather open. As a rule, it could not well be used in dense plantations of either soft maple, boxelder or other species forming a very heavy shade. For the reasons already given, this system is not as desirable as some of the others already described.

SPECIES USED IN REPLANTING

A list of trees suitable for replanting by this method will be restricted, except under exceptional cases, to those which are tolerant of shade. This list will include:

Norway spruce	Hard maple
White cedar	Soft maple
Red cedar	Basswood
White spruce	Boxelder

In no case should trees intolerant of shade be used except where it is evident that they will not become overtopped by the adjoining trees. It might sometimes be possible to use a fast-growing, intoler-

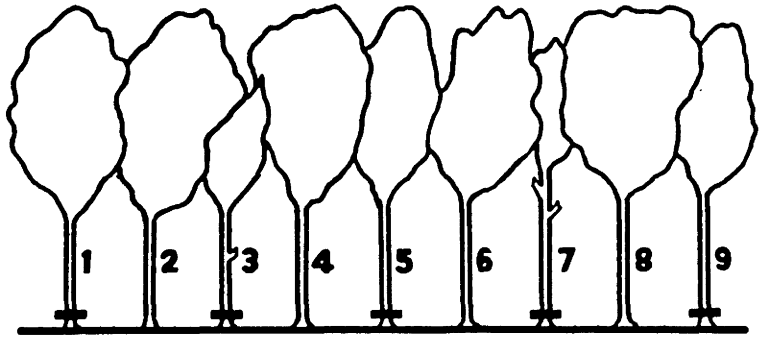

Fig. 15. Alternate rows, 1, 3, 5, 7 and 9, are removed at the start. Also remove broken, suppressed and otherwise defective trees in rows 2, 4, 6 and 8. Replant the open rows and blank spaces the same year. Only shade-enduring trees should be used except for the outside rows.

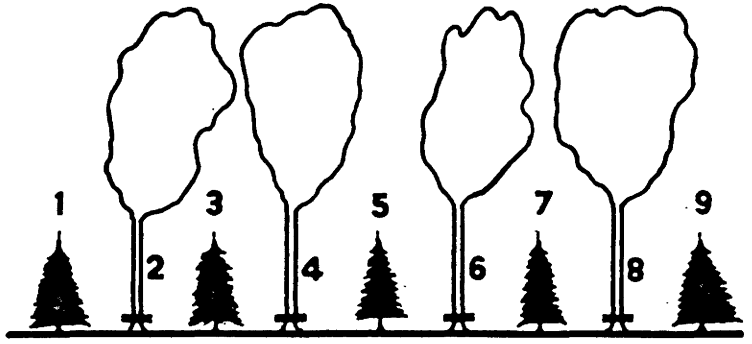

Fig. 16. At this period the regeneration is only partially completed. The remaining trees in rows 2, 4, 6 and 8 should be removed and replanted.

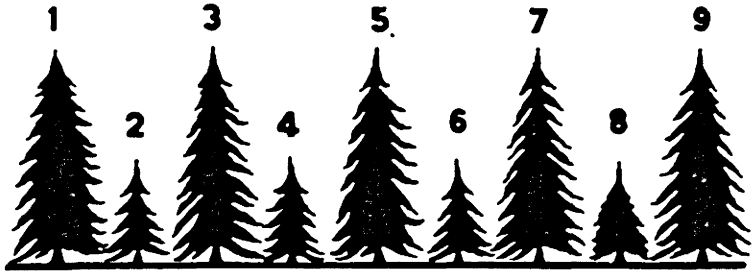

Fig. 17. The trees of the first replanting are 20 years old, rows 1, 3, 5, 7 and 9, and those of the second replanting are 10 years old, rows 2, 4, 6 and 8.

ant tree, such as the cottonwood, for planting in the rows taken out during the second cutting. For example, if Norway spruce were planted in rows 1, 3, 5, 7, and 9 (see fig. 17), and cottonwood in rows 2, 4, 6 and 8, ten years after the Norway spruce had been planted, there is little question but what the cottonwood, in a few years, would overtop the adjoining Norway spruce, since the former is much more rapid in growth.

REGENERATION BY UNDERPLANTING

The object of the method of underplanting is to provide for a new growth of trees under the shade of the existing stand, without the removal of any except diseased or suppressed trees for a period of years. This method can only be used profitably in plantations where the original spacing was rather wide, or at least only in plantations where there is some direct light reaching the ground.

It is evident that in planting new trees between the old rows without the removal of any of the old stand, only the most shade enduring species can be used. This point should be thoroughly kept in mind, since a considerable loss and much delay might result in underplanting with the wrong species. Aside from this the greatest disadvantage is in the removal of the old stand of trees after the young growth has developed for 5 to 10 years in the shade. It is impossible to cut and remove the large trees without breaking and damaging the young growth to a greater or less extent. (See cover page figure.)

The system would be most applicable to relatively young stands of trees in which a reinforcement of evergreens is desired, as, for example, a young open stand of cottonwood trees might very well be underplanted with such a tolerant tree as the Norway spruce.

The proper time for cutting out the old trees must depend entirely upon conditions, and it is impossible to specify any definite time. The removal of the large trees might either be gradual or be done at one operation. In any event, the overtopping trees should be taken out when the new growth is being crowded or is suffering from lack of light. In certain stands of a very open nature, the trees making up the underplanting might be permitted to grow to a large size without cutting out any of the overtopping trees. However, this would be an exceptional case.

The application of this method to groves of different species depends more on the openness of the stand than on the species itself, since the system could be applied to any grove if the old trees were widely spaced. The system, as a rule, will more generally apply to cottonwood and willow plantations than to soft maple and boxelder groves, since the two former are never found in as dense a stand as the last two.

SPECIES FOR UNDERPLANTING

As previously stated, only tolerant trees should be used in this method of regeneration. The following trees are suitable within their range and under proper soil conditions, for use under this method:

Norway spruce	Basswood
White spruce	Hard maple
White cedar	Soft maple
Red cedar	Boxelder

The above list of trees might be used in various combinations successfully.